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ABSTRACT

This paper describes a hypermedia system that can be used to teach electrical engineering at the university level. The system has a decision-making and data-handling capacity which serves to guide both teacher and student as to the degree of students' acquisition of learning objectives. The main advantages of the system are: (1) guidance in the study of a subject; (2) increased level of participation; (3) self-evaluation to monitor learning; (4) updated material offerings for students; (5) provided resources for teachers; (6) tutored distance learning; and (7) teacher-student communication. (WRM)

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Application Of New Teaching Technologies In Electrical Engineering In The University

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Abstract *- Hypermedia Systems are being increasingly used as tools for obtaining information and are proving to be very effective instruments in the world of education, making up for the shortcomings of traditional methods.*

The advantages offered by Hypermedia Systems are numerous, since the student can choose from a set of links how he wishes to proceed on his way through the system, thanks to interactivity, which is one of the most characteristic properties of hypermedia. Moreover, in order to overcome the limitations of traditional Hypermedia Systems which present information in one direction only (from system to user), it has been endowed with the property of being adaptable, both to the student profile and to decision-taking. This is based on the information obtained about the student, which will be modified throughout the time the student interacts with the system.

Our System is based on triggering a learning-follow-up-evaluation of the student through the carrying out of objective tests accompanied by personal reports. Hence the student, after acquiring some basic knowledge on a specific topic of Electrical Engineering, will be able to ascertain his stage of learning by means of the undertaking of different objective tests. His answers will not only provide information as to whether he has passed the test, but also will indicate the concepts he needs to study further. He will also be able to gain access, at any given moment, to an explanation of the test in question, and through the help of hypertexts, will be able to navigate towards the information that he would have needed to know in order to answer the item correctly.

The System pursues a form of teaching which is closer to the student and adapted to his specific needs, as it is capable of adapting the test contents according to the changing knowledge of the student. This increases accessibility and provides him with the opportunity to do more advanced tests which are aimed at evaluating more complex concepts, using previous achievements as their base.

The teacher will, at all times, be aware of the current situation of each of the students, since the programme, with the aid of an e-mail server, will keep its data-base updated, thus achieving an individualised assessment of the student, something which is impossible in Higher Education in Spain, due to overcrowding in Engineering classrooms.
Previous papers have shown the efficiency of the use of objective tests in university studies. Hypermedia Systems are currently being used as a complement to university studies, with a notable improvement in results.

Introduction

This paper presents a data-bank of items for studying Electrical Engineering. This system, once adapted and coupled with the latest computer technology, provides a novel and efficient form of monitoring students. This system has a decision-making and data-handling capacity which serves to guide both teacher and student on the degree of acquisition of learning objectives. Evaluation and self-evaluation guidelines and techniques which could be of great value in the held of Education have been developed. Student participation and originality have been encouraged throngh the Creativity Test, which makes full use of the possibilities offered by the latest computer technology [1]. The teacher receives assistance from the program in correcting the items designed by the students, and, in the case of these items which are structurally correct, to exercise a form of quality control, thus allowing those items which meet certain pre-set characteristics to be incorporated into the data-bank.

Educational Aspects

Users To Whom The System Is Directed

Initially, the internal organisation of the system allows it to be used by any student studying Electric Circuits subjects in the field of Electric Engineering at the University of Cantabria. Nevertheless, new guidelines

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can be introduced to cover other subjects which are not contemplated in that field of Science, or knowledge of specific subjects within the Electrical Engineering field, can be revised, even though these subjects might not be part of any specific university course ("recycling" courses, general courses for non-specialists in the field, ...)

In this last case, the student can choose from three different (beginners, intermediate, advanced) levels of difficulty.

Student Monitoring

Initial profile

The first time that a user initiates a session, certain data must be introduced which will help to define his/her profile.

Regarding the data with which the user will be presented:

- It will be defined according to the Study Plan that he is following and the subject he/she has selected, or if relevant, the concepts that the user wishes to study. Whatever the case, the user can select the required difficulty in the presentation of the subjects.

Regarding the initial way in which new concepts are presented:

- In the preparation of the personal file, a first connection with the college data bank where the student is registered will be established. A data-flow from this bank to the system will be initiated, providing the student's relevant exam results up to date and information on the subjects which the student is currently studying, and which are related to the course.

From this profile, information is obtained about which topics each student requests from the system and about the basic knowledge of each student on starting his sessions.

It may be of interest to obtain information about individual student's preferences regarding the presentation of information on aspects such as: font size, background colours and capacity for assimilation according to the medium exposed; that is, some students may prefer a sound presentation rather than a written one. In some circumstances, it might not be possible to use some of the mediums available (for example, a sound presentation might not be appropriate in a crowded classroom, unless headphones are available).

Profile modification

The system shall dispose of several parameters to carry out the dynamic modification of the student profile. The purpose of this is to ensure that the user is, at all times, searching for information which he/she is capable of understanding and that this information is presented in the right order (for example, the student should not attempt to learn about the measurement of power in three-phase systems before he/she has acquired some knowledge of the measurement of power in single-phase systems). It should be noted that, whatever the level (profile) being studied by the user, he/she shall not be aware of the existence of certain information if the system considers that his/her profile is not suited to this need [4], [5]. This is in order to avoid the discouragement and frustration which might result if the student were to find out about the existence of certain information to which he/she is refused access by means of such typical messages as "You are not an authorised user".

Selection of modifying parameters

If the main components of the System's Data Hyperbase are Objective Tests, Application Problems, Hypertexts and References, it should be the results of the use of this information which "tell" us about the student's progress.

The following are the possible informative parameters:

- Objective Tests passed [5].
- Analysis of answers to non-objective tests passed.
- Hypertextual information Visited.
- Time used for each visit and ratio with respect to the recommended solution to the item.
- Personal Comments from student to teacher (via e-mail).
- Analysis of solutions to problems posed.
- "Surprise" evaluation by System, based on tests and problems, revising material presented previously.
- Results of exams taken by students.

Monitoring By The Teacher

Once a new system user is configurated, a flow of information is established from the environment to the teacher. The teacher will, at all times, dispose of information concerning the progress both of individual students and groups of students.

To this end, data will be sent from the System and via e-mail to the teacher in charge of the subject, so that the teacher (by means of a satellite programme) will have a file for each subject which he is in charge of, made up of the student-users of the System. This file will contain individualised information on each of the students. This allows the teacher not only to follow each student's progress but also to compare his/her progress with that of the rest of the group. A further possibility is to configurate the profile of the average student by comparing the differences in performance between various groups.

In the case where a University Tutor is participating in the course, he/she will have access to information on all of the students, even if these students are from different study plans and academic years. This

information provided by the System will enable the Tutor to guide the student in the subjects dealt with by the Hypermedia System. In this way, the Tutor can act rapidly, without having to find and consult the other teachers involved, although such consultations should be pursued when appropriate.

Evaluation By The Teacher

Each teacher can establish his/her own evaluation criteria, deciding how much value to place, for example, on the Theory side and on the problems and partial tests.

Structure Of Items

Each item will have its own identifier, so that they can be distinguished from each other. Whenever a new item is introduced into the data-bank, this identifier will be created automatically by the System.

When a new item is introduced, the following information should be supplied to the System:

- Corresponding Didactic Unit.
- Objectives to be reached on succesful completion of test.
- Title of the Test.
- Six answers, including the correct one.
- Explanation of the correct answer.
- Short explanation of all answers.
- Degree of difficulty (this degree of difficulty will subsequently be compared by the teacher in his/her revision of items, with the real degree of experience in the use of the item by the user).
- Classification of each distractor, according to criteria such as: Operating Error, Serious Conceptual Error, Minor Conceptual Error, ... •
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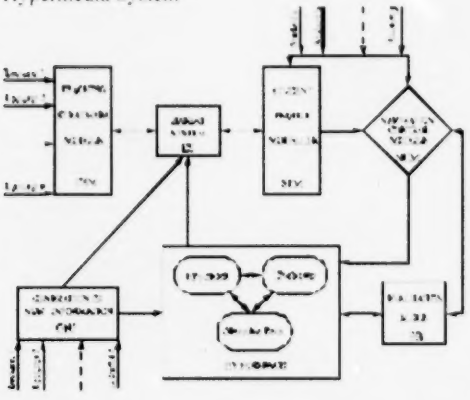
Description Of The System

The next figure shows the general diagram of the Hypermedia System



SPM (Student Profile Modeller)

This module will decide on the level of learning appropriate for each student or group of students [7].

Using the initial profile as its starting point, the module will evolve according to the guidelines provided in the Expert System. The aim of this is to adjust the material available in Hyperspace to fit the needs and possibilities of each user. Furthermore, each user will be able to personalise the qualities of the material to suit his own preferences: preferred background colours, choice of medium (sound, images, etc). (future development).

In this module, the students themselves and the decisions provided by the Expert System (ES) will act as the input, while the Navigation Control Module (NCM) will act as the output.

We can broadly distinguish three different types of System user, according to the knowledge displayed in a certain area-beginner, intermediate and advanced. Movement between these levels will take place when the ES judges it apropiate.

By means of this Module, the student can be given a wide range of information regarding his individual level and that of the group.

The broadest level of operation foreseen would be to start with an initial profile of beginner's level and with knowledge of Physics and Mathematics of Secondary Education level. This would mean that the Student Profile Module (SPM) would place the student at the lowest level and make the NCM show all of the basic information which is mathematically simple. From then on, the student would progress stage by stage, and the presentation would reflect all of the necessary mathematical requirements.

TSM (Teaching Strategies Module)

All of the teachers involved in the use of the System will have access to this module. It is intended that all the data required to "personalise" the results obtained by the System should be introduced in it.

The teacher will have to design his own evaluation system. That is, he will decide what weight to give to the results obtained from the problems, those obtained from the exhaustive analysis of the visits to the theory notes (hypertexts), the conclusions reached by means of the Objective Tests and the dates on which the student interacted with the System (whether they were close to exam-tines or intermittent).

The module must allow for the introduction of the characteristics by which the EB (Evaluation Block) is to be guided, that is, the number of Objective Tests which must be answered in order to obtain the final evaluation and the average difficulty of these tests. This difficulty can be measured in each item file and will have a suitable refeeding capacity, so that it can vary according to the results obtained in the various student's answers. Thus, the System will be able to select, at random, a specific number of Objective Tests according to the difficulty established previously. These

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tests can then be used for the evaluation of students in the system itself, or can be printed up and used in traditional exams.

In the TSM, it will also be possible to select same data to be sent to the teacher by e-mail, according to the preferences of each teacher. Hence, it will be possible to individualise to some degree the teacher's monitoring of the student.

NCM (Navigation Control Module)

Working with hyperdocuments in the field of education is a new back-up method for a form of teaching which is quite different from traditional education.

While traditional education tends to be based on the use of printed material, and generally follows a linear, step-by-step progression, the use of heperdocuments can provide a multi-dimensional, non-linear form of presenting knowledge divided into small units of inter-linked information, thus creating a knowledge network.

One of the main disadvantages of the use of hyperdocuments is the danger that the user, when faced with such enormous dimensions, will be disorientated and even get lost in it. [2], [3].

Our system is designed to take advantage of the possibilities offered by the use of hyperlinks between documents, objective tests and problems, and to make it easy for the user to visit each of these nodes as desired. The purpose of this is to give the user complete freedom of exploration [8] within certain limits established by the System [9]. These limits depend on the profile of each System user, in keeping with the data provided by the SPM. They will be established dynamically, that is, they will vary as the student profile varies.

In order not to demoralise the student, he/she will, at all times, have the impression of being in a space without frontiers. In other words, he/she will not be aware of the existence of the hyperdocuments to which he/she does not have access, since the opening or closing of these documents will always depend on the student profile.

Thus, the Navigation Control Module will solve some of the problems posed by the use of large volumes of hyperinformation in the educational field, providing the student, whenever possible, with some degree of control over the information available [6].

GNI (Generation Of New Information)

The proposed system allows new information to be introduced by non-specialist personnel, thus reducing the onus on the teaching staff. It is intended that the information bank should grow as and when the teaching staff consider it appropriate.

All new generation Objective Tests must fulfil a series of requirements established previously before they can be added to the System's hyperspace, that is, they must meet the requirements laid down in the section on item structure. This is in order to guarantee the correct functioning of the ES and the rest of the modules that make up the application.Another facility provided here is The Creativity Test, in which the student can create new items. In this test, the System randomly provides the student with a mute circuit, and it is the user who has to draw up the text for the item and provide the various possible solutions. Once completed, the application will carry out a simulation to determine whether the correct answer provided by the student corresponds with the actual functioning of the circuit. If it does, the item will be validated. If the item is added to the item band, its degree of difficulty will be tested. The System itself will determine the level of the test, according to the results obtained from the rest of the user's answers (degree of difficulty).

The aim of this module is to encourage the student to participate with his/her own expertise, and, at the same time, to enhance the data bank with independent contributions other than those of the teachers. The task of the teacher will be to test the degree of originality of the item and, using the data provided by the System, to assess its intrinsic quality. He/she can also analyse the degree of knowledge displayed by the student's choice of distractors and whether these correspond to the most common conceptual errors.

EB (Evaluation Block)

This block is the unit which controls, studies and classifies the answers given by the student to each of the items. It presents the messages corresponding to the individualised reports made from the answers given. It will also count the number of errors and correct answers given, and detect the category of the error made.

When marking a test, it will follow the criteria established by the TSM, so that the final result given by the EB will depend on the strategy selected by the teacher.

It will ensure that the control over the degree of difficulty of each of the tests is kept up-to-date and it will make calculations to establish the characteristics of each of these tests. The main parameters which it will provide for the teacher are :

- Number of items answered.
- Number of items answered correctly.
- Number of items answered wrongly.
- Number of wrong items corresponding to: minor, serious and very serious errors.
- Degree of difficulty of each item.
- Statistical parameters of the various groups.

Hyperspace

Hyperspace is the name given to the data-base which is handled by the System and which is interlinked. It consists mainly of Objective Tests (single answer or Multiple Choice) which cover various aspects of Electrical Engineering.

There is a set of hypertexts which contain the theoretical aspects of the different objectives dealt

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with, and which are closely related to the solutions to the tests. It also contains a series of exercises on the classic problems in this field, so that the student can attempt to understand the real situations in which the theoretical knowledge acquired can be applied.

All of this information is shown through various mediums, such as text (that is, both the characters and their associated images), sound (both sounds identified as basic functions of the systems and oral explanations of specific topics), pictures (such as successions of images accompanied by explanatory tests), and videos (particularly valid when reflecting real-life events, such as large transformation centres, substations etc.).

Through defect, there will be a total union of all the information available in the base, but these paths will be opened or closed by the NCM, thus creating sublevels of information in the hyperbase.

Fuzzy logic or Expert Systems. The latter was preferred as, given the nature of our data-base, it adapts better to a series of rules taken from initial data acquired through the use of the application. It is, after all, the implementation of this complex system of intermal rules that a teacher has in mind when it comes to evaluating a student, giving a class or formulating the objectives of a Didactic Unit.

In design stage, we opted for the CLIPS 6.0 software developed by NASA. This decision was taken largely on the grounds of the previous experience of the group with this software and the solid reputation of the same.

Basically, the ES functions as follows: it captures any event taking place in the application (activation of information nodes, answered items, running times). This sets in motion a series of rules which produce definitive data on the currents situation of each of the users. This data is used mainly by the SPM.

Conclusions

The following are the main advantages of the Systems.

- From the point of view of the student :
  - Aid and guide in the study of the subject.
  - Increase in level of participation.
  - It provides a self-evaluation system as a form of controlling the learning of a subject, something which is highly desirable at university level.
- From the point of view of the teacher :
  - It enables an individualised monitoring of the student's knowledge and progress to be carried out.
  - It allows for a constant updating of the material offered to the students.
  - It implies increased contact with the students.
  - It provides the teacher with several types of resources, validated by other teachers and by the students themselves.
- From a general point of view.
  - It makes full use of the latest informatics tools to facilitate student learning.
  - It provides a form of distance-learning which is truly tutored.
  - It encourages teacher-student communication and can promote group work among students (via e-mail, talk...).
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